The Transportable Cesium Fountain Clock NIM5: Its Construction and Performance

Tianchu LI, Pingwei LIN, Mingshou LI, Ping WANG, Weiliang CHEN, Nianfeng LIU and Yige LIN
National Institute of Metrology (NIM) China
Tianchuli@yahoo.com.cn

The first fountain clock NIM4 at NIM was constructed following the design of first laser cooling – fountain clock CsF1 of SYRTE France [1] and has been running since updating in August 2005 with operation ratio of 95% and evaluation certainty of $5x10^{-15}$ [2,3]. From 2005 we started to build the second transportable Cs fountain clock NIM5. In this paper we mainly report the construction and performance of NIM5.

The NIM5 adopts the (1,1,1) MOT/OM (magneto-optical trap / optical molasses) configuration and can use MOT or direct OM to prepare the cold atoms, but OM is chosen as the standard mode of operation considering its smaller collision frequency shift.

A master laser is stabilized through AOM (Acoustic Optical Modulator) frequency shift/modulation to produce modulation-free laser output for the injection locking of two slave lasers and detections. Six laser beams from two slave lasers, with more than 10 mW usable optical power each beam, and an anti-Helmholtz magnetic field configure the (1,1,1) MOT/OM. Machining of the MOT/OM body and direction pre-aligning of the six laser beams ensure the correlative angle deviations among these six MOT/MO beams better than 2 arc minutes from the nominal figure to load, cool and launch atoms efficiently.

The 9.19 GHz microwave frequency synchronized to an H-maser, H2, has been locked to the OM clock transition with stability of around $3.5x10^{-15}$/d (including the stability of H-maser) and the NIM5 clock has realized an operation ratio of 98% in semi-continues day to day running in the past ten months. An alternative sampling is utilized to improve the frequency locking stability by realizing one frequency locking at one fountain circle, which is 1.5 s for NIM5 working with OM [4].

Three preliminary experimental evaluations of NIM5 have illustrated a typical combined uncertainty range of $(3\text{-}6)x10^{-15}$.

We are optimizing the operation of NIM5 and especially its electronics and microwave to improve the frequency repeatability and evaluation uncertainty of NIM5, the latter is mainly limited now by the microwave power frequency shift.

The NIM5 consists of a laser-optical platform, a physical package and two electronics-control racks, all of the four are connected only by electric and optical cables. The NIM5 is supposed to be able to resume operation after adjustments after undergoing transportation so it will be moved to the NIM new Changping campus 30 km away from the present site in the near future.

The NIM4 and NIM5 (just begins) has been used to steer experimentally the master clock H-maser, H2, of the NIM time keeping clocks assembly. The first bunch of data has demonstrated that the stability and uncertainty of the NIM atomic time steered by NIM4 and NIM5 is better than by the commercial Cs clocks assembly.

With only GPS common view link available at present NIM is going to construct its TWSTFT link to PTB Germany.

The NIM5 clock will eventually run side by side with NIM4 and they are compared from each other to form the primary frequency standard for this country.

Reference

[1] A.Clairon, P.Laurent, G.Santarelli et al, "A Cesium fountain frequency standard: preliminary results," IEEE Trans., IM44, pp128-131, 1995.
[2] T.Li, M.Li, P.Lin, B.Huang et al, "NIM4 Cesium atomic fountain primary frequency standard: performance and evaluation," UFFC-FCS2004 (Montreal) pp431-432, 2004.
[3] T.LI, M.LI, P.LIN et al, "Improvements & new evaluation of NIM4 Cesium fountain clock in 2005 and construction of NIM5 clock," <Chinese Phys. Lett.> V24N5p1177-1179 (2007).
[4] T.LI, P.LIN, M,LI et al, "The Second Cesium Fountain Clock NIM5: Its Construction and Performance," Proc. of IFCS2007 International Frequency Control Symp. (Geneva) pp55-57, (2007).